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Energy certificates REC and PAT sustenance to energy model for India

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ABSTRACT

An innovative energy model is explored for techno-economic feasibility evaluation, taking into consideration the geographical advantages, government policies, regional incentives and energy certificates. In India, two energy certification schemes have been started, namely, the Renewable Energy Certification (REC) mechanism, successfully implemented in India during 2011, and the Perform, Achieve and Trade (PAT) for the Enhanced Energy Efficiency Programme in 2012. This paper reviews the state of the art in designing an energy model at a specific location, with the consideration of solar, wind and ground sources for renewable energy and fossil fuel, to gain optimum performances in energy certificate scenario.

The key design issues about boundary and target settings for REC and PAT energy certificates are discussed to review the financial performance of the schemes taking into considerations energy generators, designated consumers and traders in the market. Due to major impact of micro-medium and small industries (MSME) on Indian economy, this paper discusses the possibilities of inclusion of MSME in PAT scheme. One more addition in PAT scheme, with respect to large unit with marginal available fund for technology upgradation/financially sick unit, invites the creation of consolidated fund, which will support technology absorption and role of state Government policies for funding this mechanism.

The energy model provides the estimation and prediction of hybrid power generation in regard to the parameters of resource potential, technology, efficiency and consumption pattern. The monitoring, statistical and prediction model with inbuilt mechanism for REC and PAT incentives is explored.

Contents

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1. Introduction

After the Kyoto protocol, the United Nations Framework Convention on Climate Change (UNFCCC) had impacted the energy scenario in developing countries like India. The Ministry of New and Renewable Energy (MNRE) had created many schemes for the promotion of generation and use of renewable energy. In 2010 MNRE launched the National Solar Mission to target 20GW off-grid and grid interactive solar power generation by 2022. The Energy Star Rating Programme by the Bureau of Energy Efficiency (BEE) is one of the successful initiatives to target energy efficiency and saving. The Market Transformation for Energy Efficiency (MTEE) scheme targeted to save energy by accelerating the shift to energy-efficient appliances in designated sectors through innovative measures that make the products more affordable. UNFCCC has designed Clean Development Mechanism (CDM) for the implementation at international level for promotion of energy efficiency via technology upgradation in developing countries. India had also implemented CDM and got benefits of the scheme [1,2].

Renewable Energy Certificate (REC) is a National level policy instrument to promote renewable power generation in India. Technologies such as wind, solar PV, solar thermal, biomass and hydro are eligible to earn RECs. Such schemes exist successfully in several parts of the world. Renewable Energy Certificate mechanism in India is a market based instrument to promote renewable energy generation through renewable purchase obligations (RPO) on the energy distributor [3]. The environmental attributes can be exchanged in the form of Renewable Energy Certificates, which are tradable.

Perform, Achieve and Trade (PAT) is a market based mechanism to enhance cost effectiveness of improvements in efficiency in energy intensive industries through certification of energy saving which can be traded. The proposed implementation structure will be institutionalized through an existing institution to provide an extended hand for support to Designated Consumers (DCs) based on measurable performance indicators. The PAT mechanism is designed for review and implementation by Bureau of Energy Efficiency (BEE) under National mission on Enhanced Energy Efficiency (NMEEE) [4,5].

To meet the desired target and support renewable energy, Central Electricity Regulatory Commission (CERC), Ministry of Power, has launched the REC mechanism in consultation with State Electricity Regulatory Commissions (SERC). Bureau of energy efficiency is also working on a draft for PAT mechanism and ESCert trading under NMEEE. In global scenario, solar energy technology diffusion rate is higher due to technological improvements resulting in cost reductions and government policies supportive of renewable energy development and utilization [6]. In India during last decade, wind energy achieved the maximum growth rate in view of regional resource potential. This paper analyses the potential implementation of hybrid power plant (PV/wind/geothermal/fossil fuel) in view of an enhanced energy efficiency scenario.

2. Review of energy model promotion through energy certificate

Richter has designed a utility business model with emphasis on applying the business energy model framework as an analytical tool, and found that existing utility-side business models comprise a series of advantages for utilities in terms of revenue potential and risk avoidance [7]. Ngan and Tan explain the model with the Homer software on the potential implementation of hybrid photovoltaic/wind and diesel system in southern city of Malaysia [8]. Shi and Chew reviewed the state of art in designing a RE model specifically solar, geothermal, and day lighting system to gain the optimum performance in sustainable building [9]. Xie et al. review the status of renewable energy in 34 provinces of China and major cities with focus on national policies, local regulations and the main problems of these provinces [10]. Menegaki, using a random effect model, has studied the causal relationship between economic growth and renewable energy for 27 European countries in a multivariate panel framework over the period 1997–2007 [11]. Jebaraj and Iniyan reviewed different types of models such as energy planning models, energy supply–demand models, forecasting models, renewable energy models, emission reduction models and optimization models [12]. Iniyan et al. explain three models, namely Modified Econometric Mathematical (MEM) model, Mathematical Programming Energy–Economy–Environment (MPEEE) model, and Optimal Renewable Energy Mathematical (OREM) model [13]. The energy certification programmes across the globe are reviewed to study techno-economic feasible energy model.

2.1. European energy certification system (EECS)

Association of Issuing Bodies (AIB) has established a mechanism for the promotion of renewable and efficient energy source by creation of harmonized system "European Energy Certification System" (EECS), to provide an international platform for 18 European countries including Norway, Sweden and 3 from Belgian regions [14]. The EECS system defines the lifecycle of a Guarantee of Origin (GO) in three steps namely issuance, transfer and cancellation [15]. Poullikkas et al. used an optimization model to develop a GA technique for the calculation of both the additional cost of electricity due to the penetration of RES-E technologies as well as the required RES-E levy in the electricity bills in order to fund this RES-E penetration for European Union [16,17].

Electricity Disclosure (ED) as a requirement, was implemented for the first time in the Electricity Market Directive in 2003 and modified in 2009 with EC directive 2009/72/EC, Article 3 (9). This directive requires that suppliers of electricity disclose their electricity portfolio with regard to energy source and environmental impact, specifying the emissions of CO2 and the production of radioactive waste [18]. Valentina and Maarten summarize green certificate/REC trading in the Netherlands in view of ED [19].

RECS International is an association of market players in renewable electricity certificates with 230 members (September 2012) in more than 22 mostly European countries and its stated objective is to promote a pan-European renewable electricity market, facilitated by a commonly accepted and harmonized European information system [14].

The Italian Regulatory Authority for Electricity and Gas is working on steps to increase demand and provide certainty to investors [20].

2.2. Renewable portfolio standards (RPSs) in the United States

The US terminology for both GO and TGC is REC, which is used in both mandatory markets (under government-mandated Renewable Portfolio Standards (RPSs)) and in voluntary green power markets. The US RPS is a system which creates a market demand for renewable and clean energy supplies, based on the same principles as a Quota System [20]. Energy Efficiency Portfolio Standard (EEPS)-like laws are now in place in California, Colorado, Connecticut, Hawaii, Nevada, Pennsylvania, Texas, and Vermont [21].

2.3. Australian renewable electricity policies

The Renewable Electricity (RElec) support mechanism in Australia has been modest to implement mechanism Mandatory Renewable Energy Target (MRET). The target for RElec generation was assigned as 9.5 TW h/y on 2001 levels by 2010 and achieved well in advance [22,23]. Curran has highlighted the Australian scenario for energy prediction [24].

2.4. Energy-Consuming Enterprises Program: China

The National Development Reform Commission in China launched the 'Top 1,000 Program', which targets energy efficiency improvements in the 1000 largest enterprises that together consume one-third of all of China's primary energy [9,10].

2.5. Energy Certificate Registry, India

Central Electricity Regulatory Commission (CERC) has notified Regulation on Renewable Energy Certificate (REC) in fulfillment of its mandate to promote renewable sources of energy and development in electricity [22]. The mechanism enables CERC to issue two types of certificates, first on energy generation with solar and second on other renewables. The PAT mechanism is in draft stage for the review and implementation by Bureau of Energy Efficiency (BEE) under National mission on Enhanced Energy Efficiency (NMEEE) [4].

The Government of India constituted the National Clean Development Mechanism (CDM) Authority for the purpose of protecting and improving the quality of the environment. The National CDM Authority receives projects for evaluation and approval according to the guidelines issued by the Clean Development Mechanism Executive Board. On successful examination of the project, the Host Country Approval (HCA) is issued by the Member-Secretary of the National CDM Authority. India has issued Host Country approval for 2305 projects targeting 716590823 Certified Emission Reduction (CER) Certificates across 13 sectors till March, 2012 [26]. As on June 30, 2012, China leads with 2101 registered CDM projects accounting for 48.9% followed by India with 855 projects i.e. 19.9% and Brazil with 204 projects i.e., 4.7% of total CER. The national program PAT is introduced in view of less demand for CER in International market and also reduced CER price varying from INR 230 ($ 4.50) to INR 300 ($6.00) in September–October, 2012.

The status of renewable energy utilization in consideration to potential given added advantage to states like Rajasthan summarized by Shreemat Pandey et al. [27] but some states are lacking in this advantage like Jammu and Kashmir, summarized by Lohan and Sharma [28]. Daniel et al. considered different energy planning scenarios to reduce the total actualized cost of energy generation over selected time horizon and predict the additional installations required along with the existing facilities to meet the energy demand for the state of Tamil Nadu [29].

3. Renewable energy certification in India

3.1. Mechanism

The REC mechanism has the prime objectives of RPO regulation, increasing flexibility for participants to carry out RE transactions, overcoming geographical constraints, reducing transaction costs, developing all encompassing incentive mechanism and reducing risks for local distribution licensee.

India has been bestowed with huge RE potential on sources including solar, wind, biomass and small hydro. Central Electricity Authority conducted a survey on energy potential and highlighted India's potential of solar energy approximately at 5000 trillion kWh/y equivalent. The combined potential of various RE sources excluding solar energy, in some major states in India, is shown in Fig. 1 [3,30]. The states, after considerations on the potential of REC as highlighted in Fig. 1, have announced promotional benefits for renewable energy. These benefits are in the form of accelerated depreciation benefits, tax benefits, generation based incentives and capital subsidy. Further, CDM benefit is also available to renewable energy projects [22,28].

The Solar Mission has set a target of 20,000 MW and stipulates implementation and achievement of the target in three phases, with the first phase in 2012–13, second phase in 2013–2017 and the third phase in 2017–2022, for various components, including grid connected solar power.

Grid connected Solar Thermal power projects of an aggregate capacity of 500 MW have been selected for FY 2010–11. Solar PV power projects of about 200 MW capacity have been selected for FY 2010–11. Grid Connected Solar PV power projects of up to 350 MW capacity are selected in the Second Batch for FY 2011–12.

In this mechanism, one REC is issued to the RE generator for one MWh electrical energy fed into the grid. The REC issued by SERC has a Unique Certificate Number with information on name of the issuing body, generator identity, type of generation technology, installed capacity of the generator, location of the generator and signature of the authorized person. The REC generator must apply within a period of three months of the generation for issuance of RE certificate on grid connected RE projects of 250 kW and above [30]. Fig. 2 shows the active components of REC mechanism. The REC is available for trade up to 365 days after the date of issuance.

The RE generator identifies the RE potential and coordinates with state Government for the power sale agreement. The approved RE generator installs the RE plant and contacts state load distribution centre (SLDC) for the supply of energy to the grid and energy metering. SLDC monitors the energy distribution and certifies the energy fed to the distributor for the issuance of REC by CERC. The RECs issued by registry are tradable at two power exchanges within 365 days.

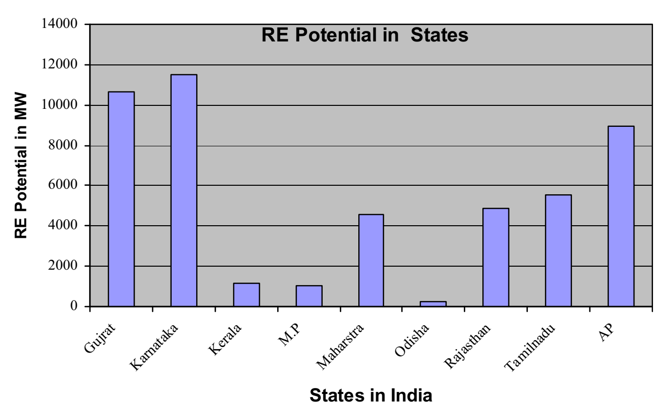


Fig. 1. State-wise Gross RE Potential Capacity (Excluding Solar).

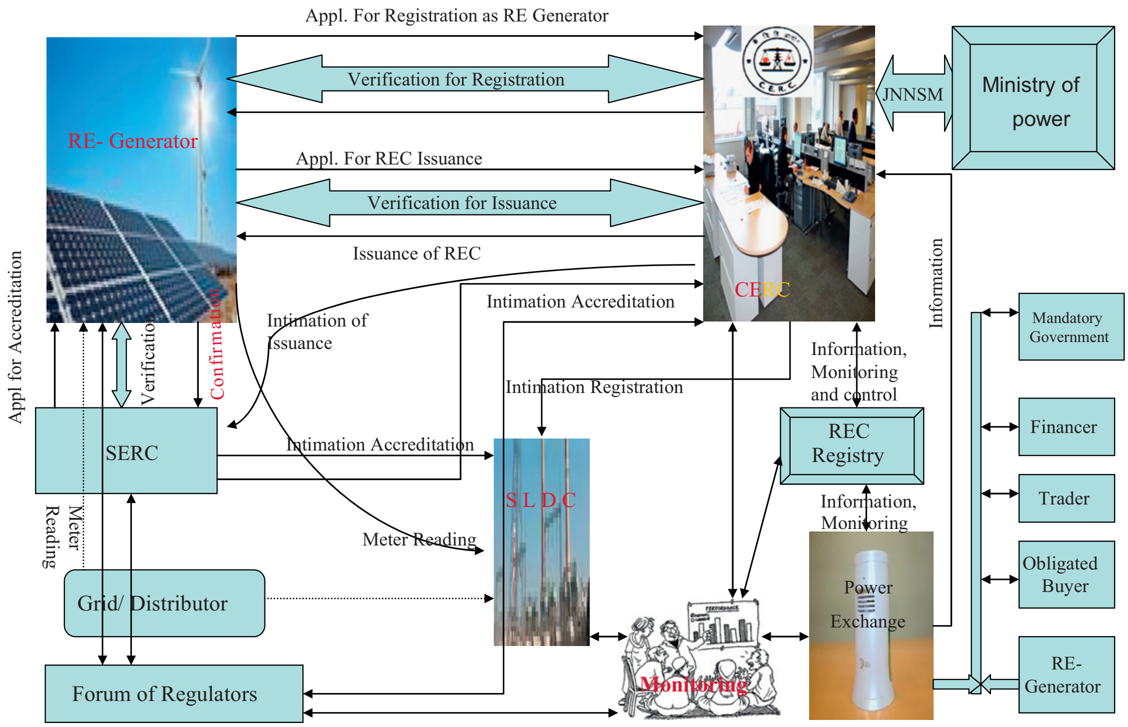


Fig. 2. REC Operational Institutional Framework—India.

Table 1
Indian statistics with e-RPO obligation of 5% or more, as on 30th November, 2012.

Serial no.	State/UT in India	RPO (%) 2012–13	Serial no.	State/UT in India	RPO (%) 2012–13
1	Andhra Pradesh	**5.00**	8	Odisha	**5.50**
2	Chattisgarh	**5.75**	9	Rajasthan	**7.10**
3	Gujrat	**7.00**	10	Tamil Nadu	**9.00**
4	Himachal Pradesh	**10.25**	11	Uttar Pradesh	**6.00**
5	Jammu and Kashmir	**5.00**	12	Manipur	**5.00**
6	Karnataka BESCOM, MESCOM, CHESCOM.[a]	**10.25 (for > 5 MW CPP)**	13	Mizoram	**7.00**
	For other suppliers	**7.25 (5% RPO on CPP and OA)**			
7	Maharashtra	**8.00**	14	Nagaland	**8.00**

Renewable Purchase Obligation on Captive Power Plant and Open Access.

[a] BESCOM, MESCOM, and CHESCOM are the electricity supply companies in Karnataka.

3.2. Renewable energy purchase obligation

The Electricity Act 2003 (EA 2003) sets Renewable Purchase Obligation (RPO) targets for distribution companies to purchase a certain percentage of their total power requirement from renewable energy sources [31]. The RE generator may sell electricity to the distribution company and the associated RECs to the distribution company or any other obligated entity. The RE generator may sell RECs to the entities with RPO target in the State or outside the State [32]. The methodology to identify RPO obligation as given in Table 1 depends on the following factors:

Projections of total quantum of energy required for sale in the State and Central Government policies.

- Potential for different types of renewable energy in the State and quantum of energy.
- Currently being generated by renewable sources within the State.
- Technical and Commercial impact of renewable power on the retail tariff.

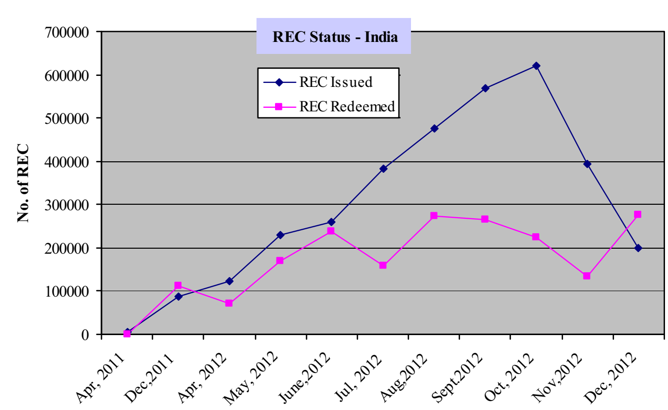


Fig. 3. REC status from April, 2011, to December, 2012.

The trading of REC is on two exchanges with centralized information and control mechanism at Central Electricity Regulatory Commission (CERC). The REC Trading started in April,

2011, with a slow response but has gained momentum within a few months operated through two exchanges PXIL and IEX. These exchanges offer easy access, transparent and fully electronic market place, and a robust and user friendly platform to trade on RECs. The trading from April, 2011, to December, 2012, is shown in Fig. 3, reflecting that REC certificate issuance growth rate has a sharp rise after April, 2012, due to the start of the financial year.

The RECs issued are rising continuously, while the RECs redeemed are stagnated below three lakhs, which create large closing balance. The rise in closing balance indicates the low demand for REC and the cost is likely to fall in future. The REC closing balance on 31st December, 2012, is 14,86,111 and floor trade price for non- solar REC is INR 1500 ($ 28) and for solar REC is INR 12620 ($ 230).

4. Perform, achieve and trade (PAT)

4.1. Mechanism

To enhance energy efficiency in industries, a new mechanism 'Perform, Achieve and Trade' (PAT) is designed with the basic green energy concept to comply with international policy similar to the Energy Efficiency Portfolio Standard (EEPS) mechanisms in the United States, Tradable Green certificates (TGC) in Europe and similar programmes in other countries [33]. The PAT mechanism is designed to promote enhanced energy efficient technology to be adopted by industry to improve target on specified specific energy consumption (SEC) in a cost-effective manner. Perform, Achieve and Trade (PAT) needs improvement to give its operational mechanism scale, complexities, timelines for successful delivery.

Bureau of Energy efficiency (BEE) is the centralized agency for the implementation of the PAT program and it will start trade on certificates by 2014. The PAT mechanism targets energy incentive sector, and identifies eight sectors for the first phase of 2012–15, namely, Thermal Power Plants, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron and Steel and Aluminum. The PAT framework has a methodology for identification of designated consumer (DC) and currently 478 DCs are working with BEE in eight sectors. The design phase includes calculations for setting up SEC for each DC and reduction target [4]. The monitoring and verification of SEC of each sector and DC in specified period with respect to base line for the issuance of Energy Savings Certificates (ESCert) are proposed. The additional certified energy saving is rewarded in the form of ESCert that can be traded with other designated consumers who may have deficiency in reduction of targets. The network and methodology for the trading of Energy Savings Certificates is proposed in this study. The centralized agency monitors issuance of ESCert by registry and trade at exchanges. This agency generates records for creation, trading and cancellation of ESCert to enable cross-sectoral use of ESCerts and their synergy with renewable energy certificates [34].

The designated consumers account for 25% of national GDP and about 45% of commercial energy use in India. The energy efficiency improvement targets are "unit specific" and each DC is mandated to reduce its SEC by a fixed percentage based on the SEC baseline within a sectoral bandwidth.

The flow chart for the implementation of PAT mechanism in India is shown in Fig. 4.

4.2. ESCerts trading

BEE in coordination with the Ministry of Power, Ministry of Finance, Ministry of new and Renewable energy and Ministry of Science and Technology prepared a draft design of PAT assessment document (PAD), which contains the information on process and technology upgraded which reflected in the form of enhanced energy saving. The PAD document contains critical information on technology, energy consumption, energy consumption for the previous year period to quantify the energy saving on technology upgradation. The assessment of PAT and claim for energy saving

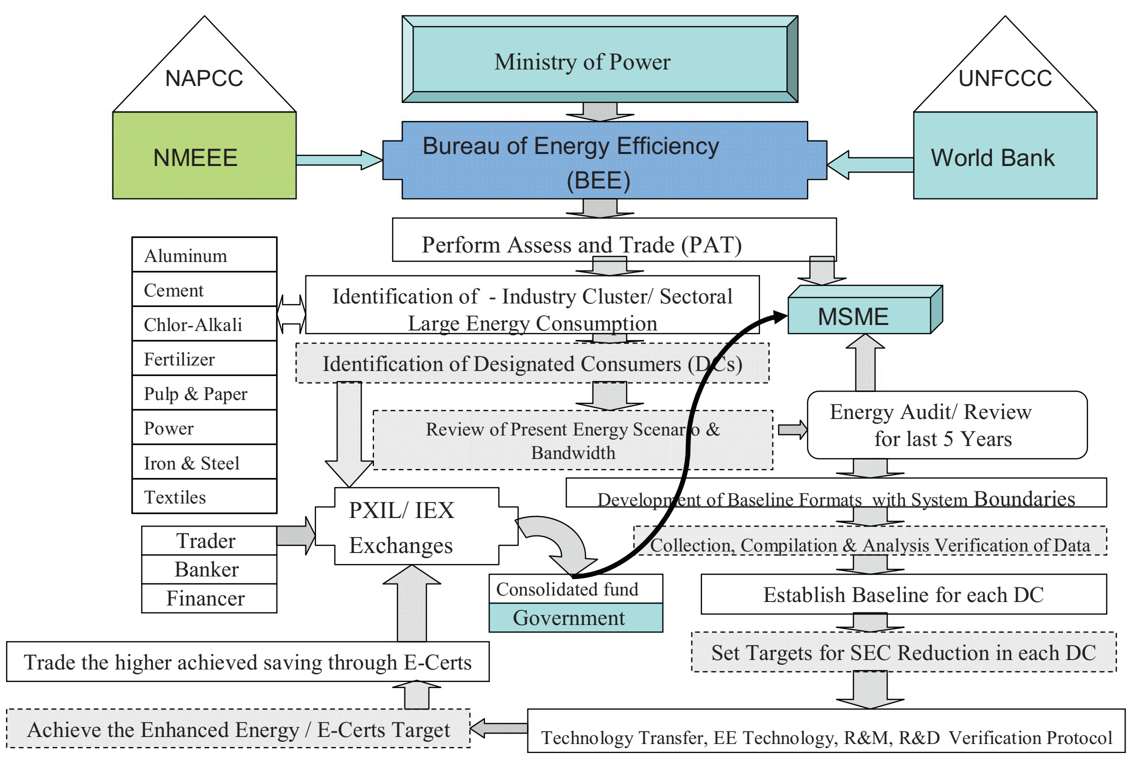


Fig. 4. Flow Chart for the implementation of PAT in India.

certificate is voluntarily declared by self-assessment by the energy manager of the DC. The PAT is registered after verification of SEC at the designated consumer for the particular time span and compared with baseline issue of the ESCert equivalent to saving on energy [5].

This paper proposes ESCerts trading mechanism and methodology that needs extensive information exchange between Designated Consumers (DCs), State Designated Agencies (SDAs), Designated Energy Auditors (DENAs), Power Exchanges, Bureau of Energy Efficiency (BEE) and Central Registry on a regular basis. The central registry office is assigned responsibility for creation of the information network and sharing timely and accurate information while maintaining confidentiality, transparency and security. This could be achieved through adopting dedicated software program PAT-Net, an online integrated information system for the operation and data management for creation, transfer, trading and cancellation of ESCert. The PAT-Net is an information consortium and provides connection to all the BEE, DCs, SDAs, DENAs, Trading exchanges, Central Registry, trader and banks. Each one of them will be provided with a unique access depending on their category, with user rights assigned accordingly. In the proposed model, PAT-Net, overall administrative control, rights and responsibility are entrusted on BEE. A single PAT-Net connecting all the stakeholders and participants ensures implementation of common standards at all the levels and promotes consistency [35].

The consolidated fund is proposed for the implementation of PAT scheme for partial support to financial debit entity and company with limited fund for technology upgradation to enhance the energy efficiency. Part of consolidated fund is plan for promotion of a parallel scheme for medium and small enterprises (MSME), PATMSME and promotion of the discussed PAT scheme. The program success depends on the availability of enhanced energy efficiency technology to fit into techno-economic feasibility under PAT scheme. The technology supplier plays a major role in the successful implementation of the PAT scheme and also the major financial beneficiary from the implementation of the scheme is included to share the risk on technology development and adaptation.

5. REC and PAT diffusion in energy model design for techno-economics of energy generation and distribution

In order to achieve the most accurate predictive analysis, influential factors in energy application have been taken into full consideration during design of energy model in this article. Taking the collected abundant data and related economic indicator models into account, further strict calculation can be used to predict relative economic indicators. Three typical renewable energy sources, namely solar, wind and geothermal energy have been taken into account in this paper to explore the design thinking of the energy models [36].

5.1. Solar energy photovoltaic power

Photovoltaic power is the direct solar energy utilization form with non-polluting, effective and easy power generation which can be either independent running or parallel running. The independent running of solar energy photovoltaic power generation system requires battery as the energy storage device, chiefly adopted in remote areas without power grid and dispersed populated areas. But the whole system is rather costly. In areas where power grid is available, the parallel running not only lowers down the cost greatly, but also is highly efficient with environment friendly features.

For the technique to collect global solar radiation, solar radiation capacity and parameter of effective radiation surface area of the solar cell array for evaluation of solar energy photovoltaic efficiency applied, the economic indicators used to calculate are as follows:

1. The global solar radiation IR obtained from the surface of the solar cell array.
2. The energy in the form of electrical voltage and current produced by solar cell array is PV.
3. The inverter loss during conversion to usable energy L.
4. Substituted quantity T_{PV} of PAT for conventional energy power conversion and smart grid technology.
5. REC Certificate for the generation S_{pv}.

The solar energy photovoltaic power model with economic indicators is

$$\mathrm{ESPV}\{\mathrm{IR},\mathrm{PV},L,T_{PV},S_{PV}\} \tag{1}$$

The solar thermal system is another form of solar energy utilization. The system collects solar radiation energy through a device named heat arrester and passes it on to a heat exchanger. Such an installation is presently the most economical and technically mature product which is already commercialized. While evaluating efficiency of the solar energy arrester, the following five economic indicators shall be considered:

1. Solar energy assurance factor φ,
2. solar energy heat collecting system efficiency η_1,
3. solar water heating system efficiency η_2,
4. useful heat quantity of solar heat collecting system Q_{uf},
5. substituted quantity T_{ewh} of PAT for conventional energy power conversion and smart grid technology, and
6. REC Certificate for the generation S_{pv}

Based on the above-listed six economic indicators, the assembled indicator of solar water heating is thus obtained as

$$\mathrm{Eewh}\{j,\eta_1,\eta_2,\mathrm{Q_{uf}},\mathrm{Tewh},\mathrm{Sewh}\} \tag{2}$$

5.2. Wind energy model

The linear wind model assumes a linear (affine) dependence (within the interval [v_C and v_R]) of the wind turbine power output, P_t, on the current wind speed at the hub height v^t [34].

As $t=0,\ldots.\ T-1$, T being the time horizon in hours. In detail,

$$\begin{aligned}
&\{0 \quad v^t < v_C\\
&\{\mathrm{PR}\left(a+bv^t\right) \quad v_C \le v^t \le v_R\\
&\{\\
&\mathrm{Pt} = \{\mathrm{PR} \quad v_R \le v^t \le v_F\\
&\{0 \quad v^t > v_F\\
&\quad T=0,\ldots,T-1
\end{aligned} \tag{3}$$

It should be observed that wind speed v^t in Eq. (3) is that corresponding to the wind turbine hub height, H_{hub}, Since, in general, wind speed data can be measured or forecasted with reference to a height H_{data} that is different from the hub height, it is necessary to use an equation relating the wind speed at hub height with the wind speed v^t data at H_{data}, taking into account the surface roughness length, which is a parameter that can be estimated on the basis of the land use at the wind farm location. T_w is the factor of technology with enhanced efficiency and S_w is

the impact of REC on the energy generation:

$$E_w\{PR,\ v_C,\ v^t,\ v_F,\ H_{hub},\ T_w,\ S_w\} \quad (4)$$

5.3. Geothermal resources: Ground source heat pump

Geothermal resources have three important characteristics, aquifer, cap rock and heat source. The volume of water flow (Q), due to porosity and permeability, flowing in unit time through a cross-sectional area $A\ m^2$ is v times A. So Darcy's Law may be written as

$$Q = AK_w(H/L) \quad (5)$$

where K_w, the hydraulic conductivity, may be interpreted as the volume flowing through one square meter in unit time under unit hydraulic gradient. The highest value of K_w occurs in coarse-grained unconsolidated rocks, such as the ash layers which are particularly common in volcanic areas, but the values are also quite high in some limestone and sandstones. Here H is the effective head of water driving flow and is measured in meters of water. The pressure gradient, or hydraulic gradient (H/L) is the change in this head per meter of distance L along the flow direction [35].

The ground source heat pump is a new type of energy source utilization technology for heating and cooling by shallow terrestrial heat. It is a sort of equipment for diverting cold and heat by the principle of the Carnot cycle and the reverse Carnot cycle. The ground source heat pump is generally meant to divert the heat or cold in the earth to the needed places. The heat pump is commonly used for air conditioning or heating system. The ground source pump also utilizes the huge deposit of heat or cold in the underground earth, while in winter time to divert the underground heat into buildings, and divert cold into buildings in summer time, so as to complete the annual cycle. When evaluating the utilization of ground heat pump systems and integrated buildings, the following economic indicators shall be considered:

1. Heating condition system ratio of energy and efficiency η_H,
2. air conditioning system ratio of energy and efficiency η_A,
3. substitution quantity of conventional energy and issue of REC—S_g, and
4. substituted quantity T_g of PAT for conventional energy power conversion and smart grid technology.

The above four economic indicators are important data for final evaluation of ground source heat pump utilization efficiency. It may be described as the following:

$$E_{gshp}\{\eta_H, \eta_A, T_g, S_g\} \quad (6)$$

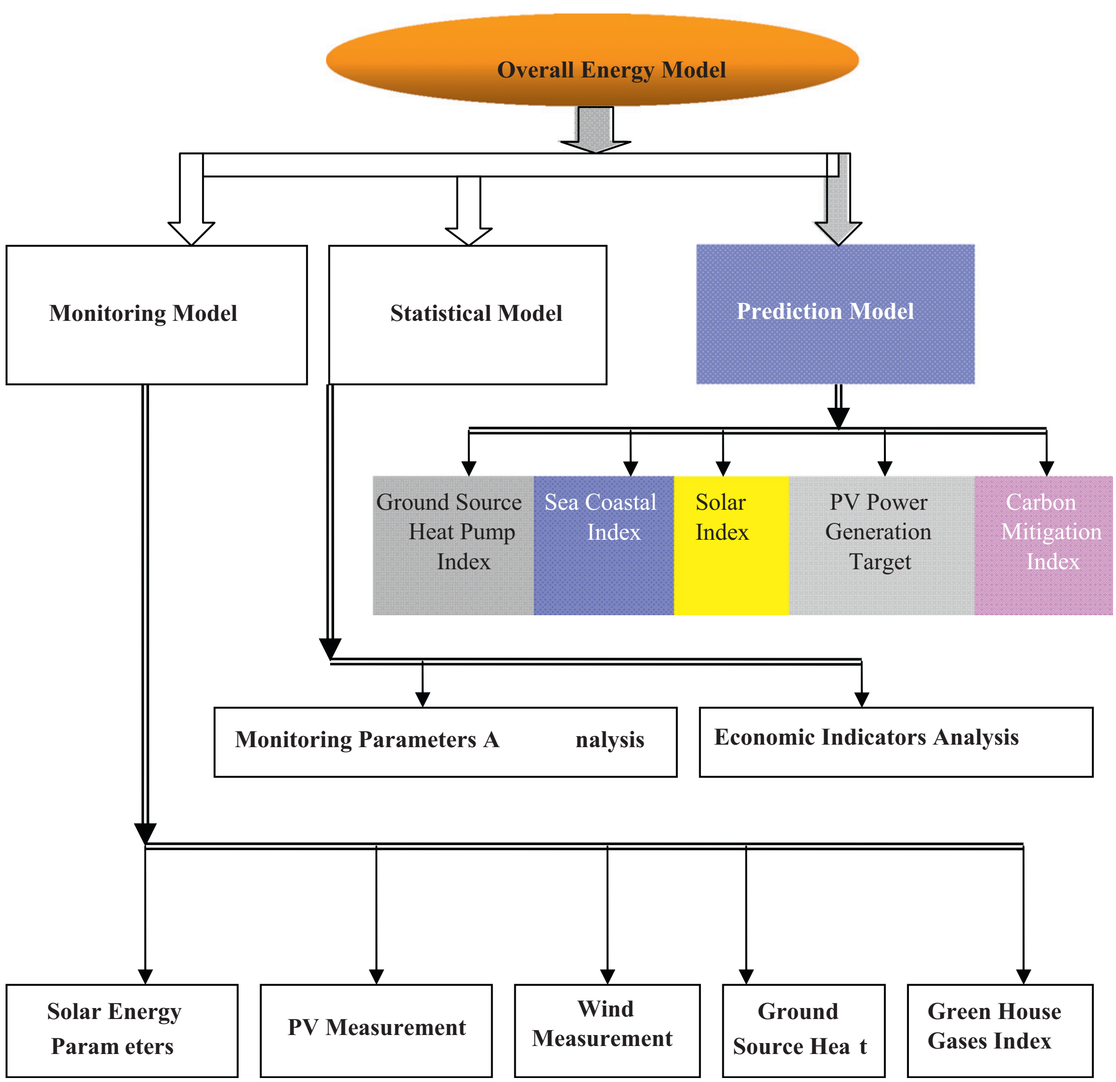


Fig. 5. Schematic of energy model parameters.

6. Energy model for REC, PAT and fossil fuel power plant

The renewable energy model is considered for the factor from Eqs. 1, 2, 4 and 6 for the availability of resources in consideration of fossil fuel energy (E_{fs}):

$$E_T\{E_{SPV}E_{ewh}E_wE_{gshp}E_{fs}\} \tag{7}$$

The Bass diffusion model [36], as considered by K. Usha Rao et al. [37] is a mixed influence model with three parameters i.e., coefficient of technology, policy and business innovation, coefficient of imitation and total potential.

$$\frac{dN}{dt} = \left[p + \frac{q}{m}\{N(t)\}\right][m - N(t)] \tag{8}$$

where p is the coefficient of technology, policy and business innovation, q is the coefficient of imitation and m is the total potential.

The Control Design and Simulation Module provides a numerical simulation environment that enables users to test the model, and the Module can be used to analyze the interactions between hybrid mechanical–electrical systems [25,38]. Furthermore, the quality of existing models can be improved and other control strategies can be investigated by simulating deep-bar induction generators and more complex models of drive trains.

The model is designed to target the following requirements of the Distributive Generation System (DGS) as explained in Fig. 5 [36].

- The model analyzes the situation and decides the data collection strategy and methodology on new and renewable sources vis-à-vis fossil fuel.
- For techno-economic feasibility the model proposes to collect and collate the relevant data on renewable potential, technology and promotional scheme required for modeling.
- Conceptual modeling for the design of integrated system like input on energy sources for the design of hybrid power plant to exploit maximum renewable energy sources at a reasonable price is applied.
- The prediction and statistical model for plan decision with additional mathematical models for simulating environmental impact is used.
- Different scenarios are generated ultimately to arrive at effective environment management plan with a view to support the decision makers.

7. Conclusion

The energy model with inbuilt mechanism for the benefit from REC and PAT explores the potential of RE sources at location of interest and provides inputs for the design of hybrid energy generation, with or without grid connectivity.

The proposed PAT mechanism in addition to operational REC mechanism gives boost to enhance energy efficiency and the use of renewable energy by industries and designated consumers. We propose to use the same platform for the trading of PAT and REC at two exchanges already started, PXIL and IEX, with different controlling institutions. This paper concludes that the following:

- Renewable Purchase Obligation(RPO) identification for all the states is the key to success for REC mechanism and the trading of energy certificates success is effected by the creation of demand to balance the supply chain. The present REC model needs to implement GO and ED mechanism in India to boost the morale of the informed consumers and also to encourage the use of renewable energy even at the higher cost.
- The REC and PAT mechanisms propose to work in interactive mode with international programs like CDM, UNFCCC and World bank. The trading mechanism may involve exchange of trade at the same exchange for REC, PAT and Certified emission reduction (CER) certificates, which may offer for exchange of one certificate with other.
- The main concern is of price stability in the yearly variations of renewable energy, which may cause large price variations from year to year. To circumvent this problem, a REC/ E-Cert market with banking (i.e. unlimited lifetime of certificates) has been the preferred solution.
- The proposed PAT program is required to focus around large industries and has a missing link for Small and Medium Enterprises (SMEs), which have major impact on the energy consumption and economic growth of India.
- One of the major stockholders in PAT scheme is the Energy efficient technology suppliers, who may get assured benefit by the promotion of the program. This paper recognizes that PAT mechanism invites obligation on this sector which mainly comprises multinational companies which are responsible for the increase in import component of technology.
- The limited access to capital for some industries, DCs, may be a major barrier for PAT. The managerial efficiency and technological challenges can also be barriers to the large set DCs from diverse industries in various sectors and at several scales.

The energy model helps to predict the minimization of the cost/efficiency ratio subject to social acceptance, reliability, demand and potential constraints. It has been observed that the energy–economy models help in understanding the way in which energy–economy interactions work. The energy modeling also enables the planners to predict and plan the future scenario in high economic growth. It has been concluded that the models serve to promote discussion and formulation of national and international policies, which are appropriate to the situation and location.

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